FINAL REPORT for NASA Grant **Temporal Monitoring of Active Comets**

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Research Summary

This work consisted of an intensive observational study of the morphology and photometry of selected active comets. The study was intended to clarify the variation of the morphology and photometry with respect to time, and to produce robust quantitative information on the temporal and morphological properties of the inner coma. The research exploited new large-format detectors and high-quality seeing at the Mauna Kea Observatories.

• Comet P/Tempel 2 was followed from the inert nucleus state at R = 4 AU to a strongly active state at perihelion (R = 1.6 AU). The nucleus was found to be aspherical (axis ratio ~ 1.9:1), rapidly rotating (period 8.95 ± 0.01 hours), and very red in the optical continuum. A fan-shaped coma developed near perihelion, and detailed high resolution surface photometry was used for the first time to study temporal variations in this coma. Curiously, the scattered continuum from the coma was neutral - in sharp contrast to the red nucleus.

We tabulated our extensive measurements of Tempel 2 in Astron. J., in the hope that explicit publication of the data would assist others to make independent interpretations of the observations (Jewitt and Luu 1989). This has evidently been a success, in the sense that Sekanina has produced a very detailed model of Tempel 2 based in large part on our data (Sekanina 1991). Without necessarily implying support for all of the conclusions reached by Sekanina, there is little doubt that this type of widespread dissemination of quantitative 2-D photometry is leading to a

vastly improved understanding of the physics of comets over that found in the literature of even a few years ago.

• Comet P/Schwassmann Wachmann-1 (P/SW-1) was also the subject of a detailed (and continuing) investigation (Jewitt 1990a, 1990b). This comet is well known to display "outbursts" of large amplitude when at $R \sim 6$ AU, canonically surging from a "quiescent" magnitude $m \sim 18$, to a peak magnitude $m \sim 12$ or 13 several times per year. From extensive time-series photometry over 4 years, we have observed a photometric character rather different from the canonical one (Jewitt 1990). Specifically, we find that SW-1 is continually active, with a quiescent magnitude $m_r \sim 15.5$ when measured in a 10" radius diaphragm, and approaching $m_r \sim 14$ when integrated out to 60". The comet displays a well-resolved, amorphous dust coma at all times, and does not decline to the state of a bare nucleus. Occasional outbursts of ~ 1 mag. amplitude were observed, but always superposed on the high plateau of continuous activity. A simple physical model was developed to explain the steady coma of P/SW-1 (Jewitt 1990). Again, we published complete tables of our extensive measurements, with the intent that others will use them in independent studies.

• Cometary activity in 2060 Chiron was studied at $R \sim 12$ AU (Luu and Jewitt 1990). The most immediate discovery was that Chiron was undergoing short-term impulsive brightening *during* the observing session. This rapid brightening was superposed on the year-long brightening associated with coma development in this object. The mini-burst of UT 1990 January 29 was apparently correlated with the near simultaneous first detection of gas in this object by Bus *et al.* Spatial photometry showed that the coma has a steep surface brightness gradient, but no evidence for a core population of gravitationally bound particles was found (see Fig. 3). The rotational properties of Chiron are now known with some confidence - the period is 5.91780 ± 0.00005 hours, and the photometric range has declined as a result of coma dilution).

The dust mass loss rate from Chiron at $R \sim 12$ AU was estimated at 1 kg s^{-1}. This tiny rate could be supplied by sublimation of CO or (less likely) CO_2 from a small fraction of the nucleus surface. Curiously, the spectrum of the nucleus in the optical is neutral, and quite unlike the spectrum of the nucleus of Tempel 2 (Luu and Jewitt 1993).

Invited reviews on Cometary Photometry (Jewitt 1991) and Application of Robotic Telescopes (Jewitt 1992) were also written under this grant.

Publications

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